EFFECTS OF PRECOOLING AND DEGREENING TREATMENTS ON THE SUSCEPTIBILITY OF PEACH AND CITRUS TO HANDLING DAMAGE

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ABSTRACT

Mechanical damage to fruits results from a combination of fruit properties and of damage inflicting effects by the handling equipment. Treatments were applied to fruits which affect mechanical damage susceptibility: precooling for stone fruits and degreening to citrus fruits. Laboratory tests (compression, impact, tumbling, abrasion) and field tests (damage in the handling lines) were applied to (3) peach, (2) apricot, (2) orange and (1) lemon varieties. Hydro- or air- cooling influence positively peach and apricot firmness and cause a significant reduction in: number of bruised fruits, and size of visible bruise, when combined with a low level of loading during handling. Degreening also affects the resistance of citrus fruits to handling, when compared to green fruits.

INTRODUCTION

A R&D transfer Project was carried out with a group of producing co-operatives in the area of Murcia (Spain). These were then leading ones in stone - and citrus fruits comercialization. In this project, a study of their harvesting and handling systems was carried out during two years, with the aim of improving fruit quality and of reducing market lots rejections due to bruising. A detailed study of the lines, as well as of the susceptibility of a number of stone and citrus fruit varieties (Garcia et al 1996;Garcia and Ruiz-Altisent, 1997) was carried out. Previous research results show that firmness and ripeness state play an important role in damage thresholds and bruise dimensions (Schulte et al., 1993; Brusewitz et al.,1991; Barreiro et al 1997). Some treatments have been shown to affect firmness and bruising susceptibility in stone fruits. In citrus fruits, degreening treatments are applied at the beginning of the season, which may affect damage susceptibility.

OBJECTIVES

The objectives of the study were: a) to study the effect of precooling treatments on damage susceptibility in selected varieties of peach and apricot, b) to study the response of selected peach and apricot varieties to the effect of the handling line in terms of damage inflicted, c) to study the effect of degreening treatment on damage susceptibility of selected varieties of citrus, d) to analyse and quantify the damaging effect of the existing handling lines, their elements and regulations. Part d) is presented in a different paper by the same authors in this Symposium.

METHODOLOGY

a) Three varieties of peaches (*Springcrest, Caterina, Sudanell*) and two of apricots (*Bulida* and *Pepito*) were studied during the 1996 season. A total number of 800 fruits were harvested in early morning (23-26 °C, 50-60% air humidity). From them, 120 were maintained in room temperature (18°C) and two further groups of 120 fruits were treated with: Hydrocooling: fruits were introduced in freezing water during 45 minutes, and then stored for 48 and 96 hours and tested before and after treatment and cold storage (2°C). Aircooling: fruits were introduced in a cold chamber (2°C) during 120 minutes, and tested as before. Tests applied were: Compression: a 9-mm diameter sphere, 20 N force (high - "H") and 10 N force (low - "L") : maximum deformation (D) and F/D ratio were used as firmness measurement of the fruits; total sugars and acid contents were also measured. Bruising caused by impact (10 - "H" and 6 - "L" cm drops by a 50 gr spherical mass) and by compression (as above) were analysed.

b) A rotating drum was used to simulate handling damage by tumbling: treatment during 30 ("H") and 15("L") seconds was applied. In a test, the fruits are impacted around the same number of times, and with similar load levels as in the existing handling lines lines. Apart from these tumbling treatments, observation of damaged fruits, before and after passing through the handling line, was carried out in the actual lines in the co-operatives. In all cases, width and depth of the observed bruises were measured.

c) Degreening in oranges, mandarins and lemons: Fruits were introduced in a degreening chamber during different periods of time, and were tested after 0, 4/7, 6/9 days, depending on the species and ripeness state. Laboratory tests which were applied to all samples were: Abrasion due to friction was applied to fruits at two levels: compression at 2.5 and 1 N during friction; compression resistance; skin puncture resistance. All tests were aplied using an Universal testing machine (Instron or Lloyd's); free drop impact (45 cm height onto two different surfaces: smooth and abrasive); impact+friction treatment applied in a rotating drum during 15 and 30 seconds; sugars (°BRIX with a refractometer) and acid (titration with Sodium Hidroxide) content were measured in all samples.

RESULTS AND DISCUSSION

The results obtained in the project relate to the characterisation of the susceptibility of the studied fruits to damage: depending on variety, treatment, firmness, and how to measure these properties; and to the design of a first step in the models to predict the level of damage which is likely to occur in a particular lot of fruits.

1) Stone fruits. Data were analyzed to determine which parameters correlated best to damage susceptibility. As a first measure, deformation in compression was selected. Figure 1 shows the relationship between deformation in compression (firmness loss in the x-axis) and bruise size (y-axis). Horizontal lines show: a) percentage of intact fruits, on the x-axis itself; b) percentage of fruits with at least one bruise between 0 and 50mm2; c) percentage of fruits showing at least one bruise > 50 mm2. Vertical lines mark the limits of 10% of damaged fruits, and 50 % damaged fruits, in both cases >50 mm2. (50 mm2 is equivalent to 8 mm diameter). Two apricot varieties

are presented. Figure 2 shows the same representations for the peach varieties. In all these figures, each point represents one fruit, T: no treatment; H and A hidro-and air-cooling respectively. All fruits are in mature state as determined by the sugar/acid contents. It is clear from these models, that deformation in compression is relevant in relation to bruise appearance; at the same time, it is shown that, unless for high deformation (soft fruits) fruits may be not damaged for similar values of firmness, so that varietal and individual fruit properties also affect bruising susceptibility of ripe peaches and apricots. This type of model representation is useful for bruising prediction, in terms both of probability of bruising and of size of bruises, as included in the present EU market standards.

Figure 3 shows, for one peach variety, tested in compression, that reducing the load from H to L levels (see materials and Methods) a significant reduction in damage probability and in bruise size is obtained, for the same fruits: In this case precooled fruits are almost all below the 50 mm2 line, and only a 4.6 % of the fruits would show bruises above this size (EU threshold is 5%). In this variety (*Caterina* peach) fruits softer than 3 mm in compression should not be handled mechanically for highest safety. When handling softer fruits (3 to 4 mm deformation), the lots would include a 23% of damaged fruits (= half the 46.1%), even if they were in the safe side of low-energy loading (i.e. soft handling)..

These results show that (at least for some varieties) a well programmed harvesting/handling system that includes precooling, uninterrupted cold storage and soft handling, is able to reduce fruit bruises to acceptable levels, not disregarding a good tasting quality of the fruit. Figure 4 shows these results for the pooled data of all stone fruits: the combination of precooling and low-load handling should reduce damaged fruits in compression (> 50mm2) by 8-10 percentage points. Similar results are expected for impact damage in peaches (apricots are little susceptible to impacts). Figures 5 and 6 show the results obtained in impact testing of all three peach varieties.

2) Citrus. Figure 7 shows the comparative results of impact, friction and tumbling on the three citrus varieties tested. The effect of the degreening treatment was not significant in any of the tests applied to lemon, orange or mandarin selected varieties. The variability in the response of individual samples was so high that it was impossible to detect significant differences. Lemon appears to be more susceptible to friction than orange or mandarin, in respect to probability of damage. Size of damage is in all three varieties sinilar, and around 1 cm2. The degreening treatment appeared to consistently increase damage susceptibility in mandarin.

In citrus fruits, damage is primarily due to friction effects (as reported by different authors). Friction should therefore be avoided when handling citrus. When a load of 2.5 - 1 N is locally applied on the surface of a fruit, and combined with frictional shearing, the probability of visible damage is 45-80% in lemon, 18-46 % in orange, 12-25 % in mandarin. This type of friction loading appears easily in handling lines when a drop (even a small one) is made on moving bands or conveyors, and is greatly enhanced by high rugosity of these surfaces (especially for dirty surfaces).

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Figure 1. Damage surface (mm2) vs. deformation (mm) (i.e.firmness) in compression, for both apricot varieties (*Bulida* and *Pepito*). T1, T2, T3: No treatment, dates 1, 2, 3; A: Air-cooling; H: Hidro-cooling. Percentages at right: no bruise; bruise below 50 mm2; bruise larger than 50 mm2, respectively. n = 360.

Figure 2. Damage surface (mm2) vs. deformation (mm) (i.e. firmness) in compression, for three peach varieties (*Springcrest*, *Caterina*, *Sudanell*). Labelling: see Figure 1. n = 360.

Figure 3. Bruising model of *Caterina* peach by compression damage: comparison between the results obtained when combining both loading levels (H + L, 20 and 10 N resp.), left, and only low loading (L, 10 N), right. Percentage of no-damage are nearly 20 points higher.

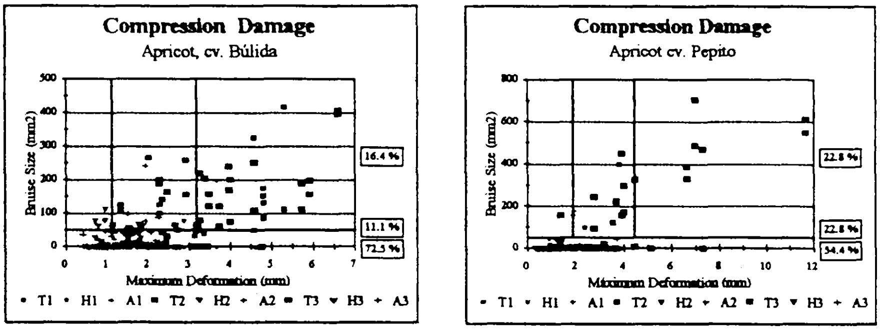
Figure 4. Pooled results for all stone varieties in compression damage, for peach varieties in impact damage tests. Percentage of fruits with bruises > 50 mm2. Left columns: All fruits (H + L); right columns All fruits(L).

Figure 5. Impact damage models in apricot varieties. Labelling described in Figure 1.

Figure 6. Impact damage models in peach varieties. Labelling as described in Figure 1. Differences in bruise susceptibility between varieties are clearly shown.

Figure 7. Effect of degreening treatment on damage susceptibility of lemon (*Fino*), orange (*Navelina*) and Mandarin (*Marisol*). NoD: no treatment; D: degreening treatment; D+48h: damage observation after 48 hrs; NS: difference is not significant.

FIGURES 1-7



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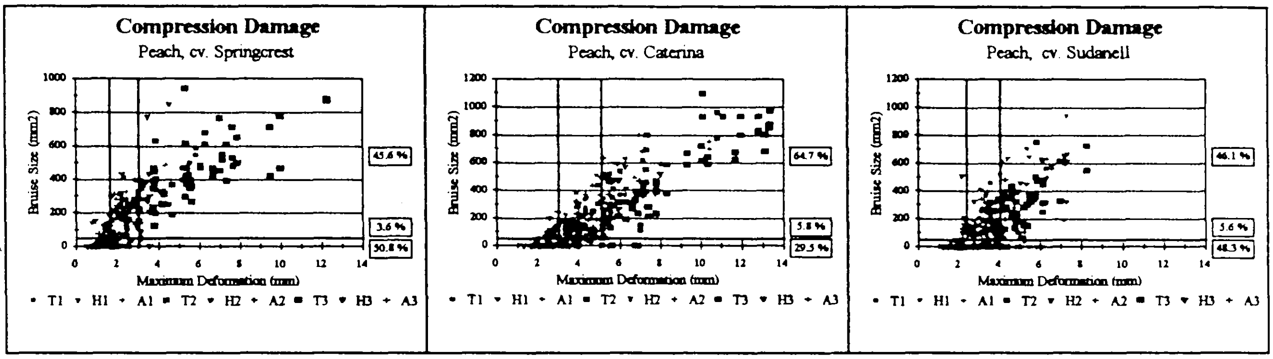

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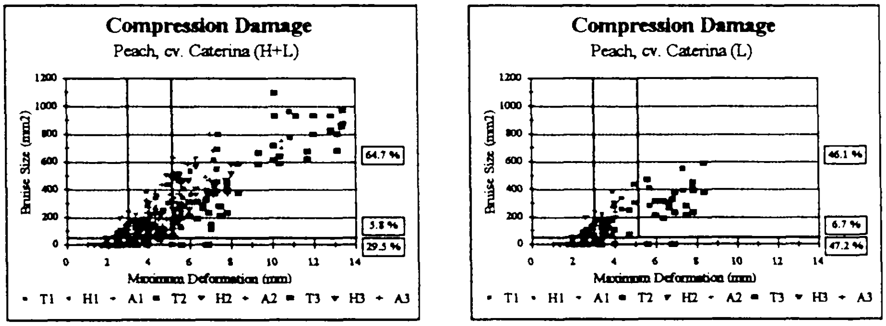

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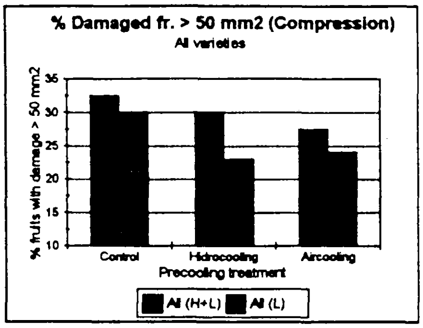

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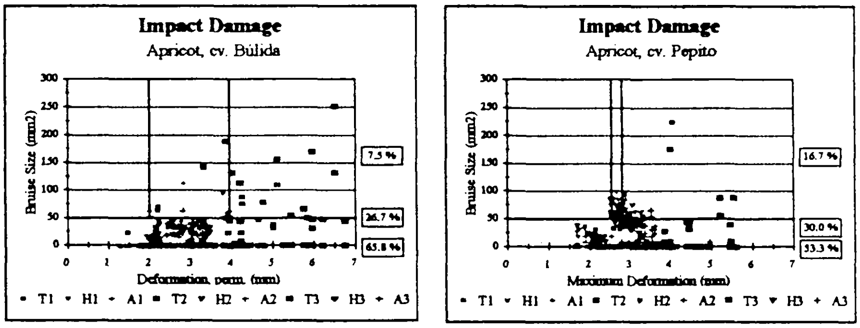

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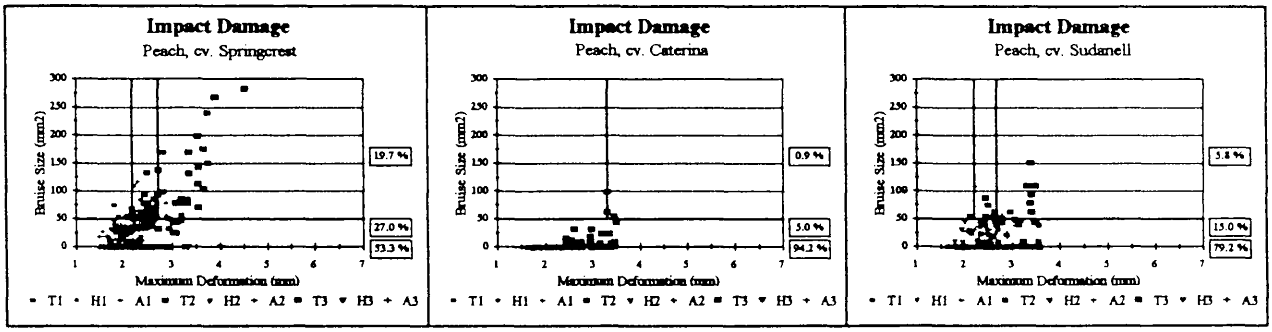

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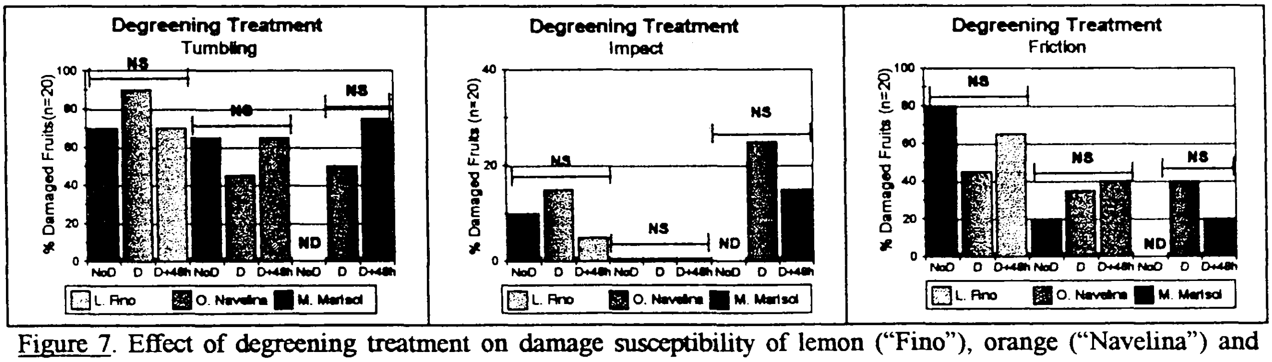

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